Use of Simplified models - introduction

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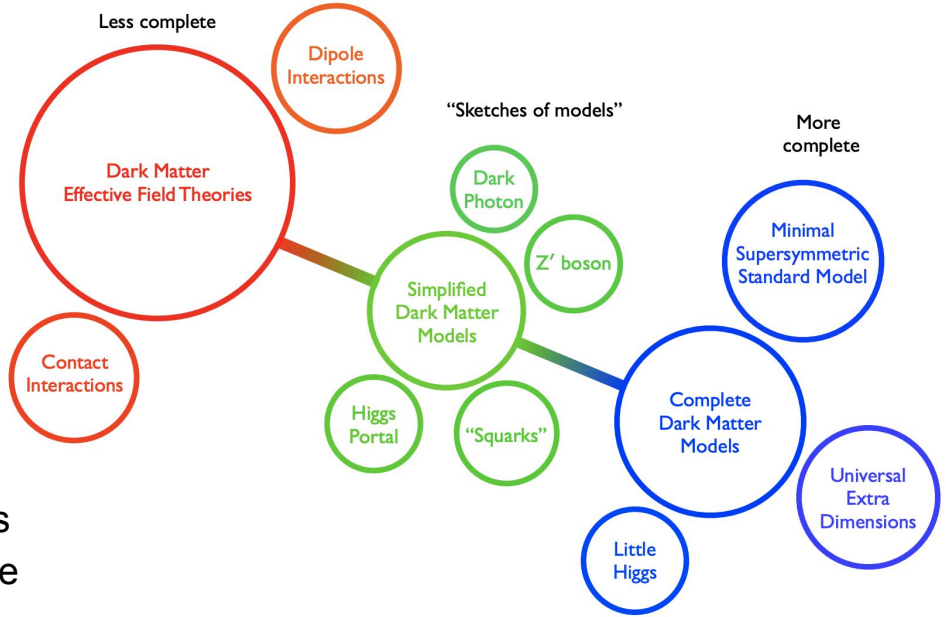
Simplified models - forging path into unknown

- Problem: Too many new physics models - impossible to test all against experimental data
- Proposal: Parametrize new physics scenarios with few masses and couplings without loss of generality
  - Fixed production mechanism
  - Fixed decay modes
- Outcome:
  - Presentation of experimental search results
  - Identification of uncovered parameter space



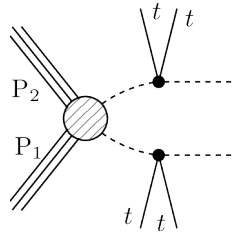
arXiv:1506.03116

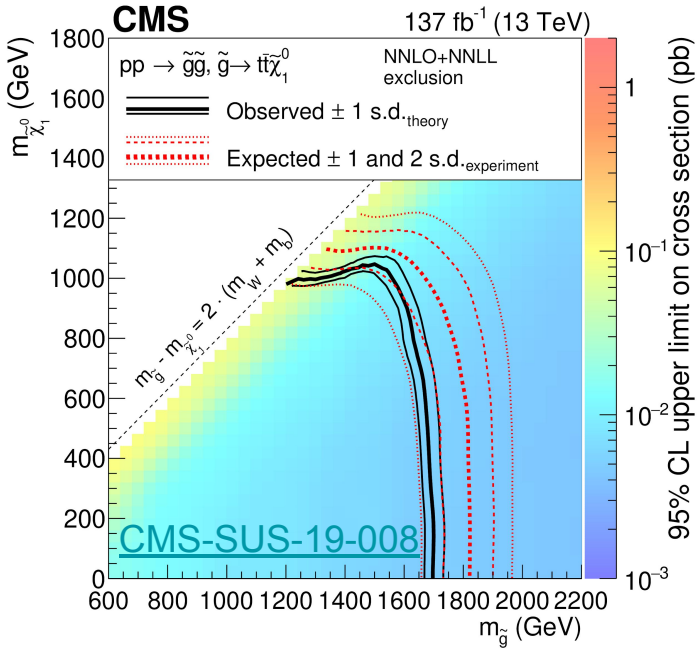
Simplified models - use cases

- Simplified models are everywhere
- HL-LHC program (extension of ongoing searches)
  - Is our susy simplified model program extensive? Do all simplified models make sense?
  - How can the DMWG program be extended in order to improve usability and scope?
- Future colliders (defining new physics benchmarks)
  - Given the expected results from HL-LHC, which new physics simplified model scenarios/benchmarks would be the most interesting to target?
- Connecting different frontiers (AF ↔ EF ↔ CF)
  - How do simplified models help us understand complementarity between different frontiers?
  - What are the pitfalls of such approaches? Would we end up over optimising anywhere?
- Defining new simplified models for new new physics scenarios
  - How do we go about exploring new new physics scenarios such as strongly interacting dark sectors and define associated simplified models which cover all possible experimental signatures?

SUSY simplified models

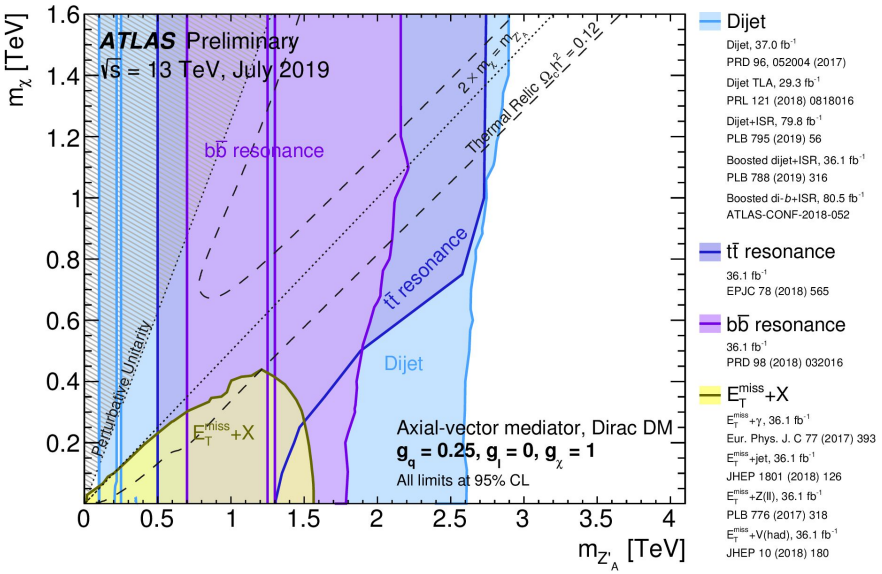
- Construction of simplified models from well defined high scale theory (MSSM)
- Three outcomes
  - Exclusion lines - give sense of progress, quick guesstimate
  - Upper limits - upper limits on production cross section σ X BR, allow to quickly estimate feasibility of same σ X BR in theory scenarios
  - Efficiency maps - parametrize kinematics, allow to combine topologies, allow to use likelihoods
- Led to development of tools e.g. SModelS, FastLim





Dark matter simplified models

- Construction of simplified models motivated by high scale theory models
  - Z' with arbitrary couplings, parameters $m_{Z'}$, m_{DM}, g_{DM}, g_q
- Can be used to connect LHC and cosmic frontiers (DMWG document arXiv:1603.04156)
- Work ongoing in EF10 to understand impact of assumptions on this plot
- Limited use for reinterpretation purposes
  - More later



LLP simplified models

- A mixture of well defined high scale theories and well motivated scenarios
- Demonstrate parameter space covered and uncovered by experiments
- Complementarity with lifetime frontier/forward experiments

See talk by B. Shuve

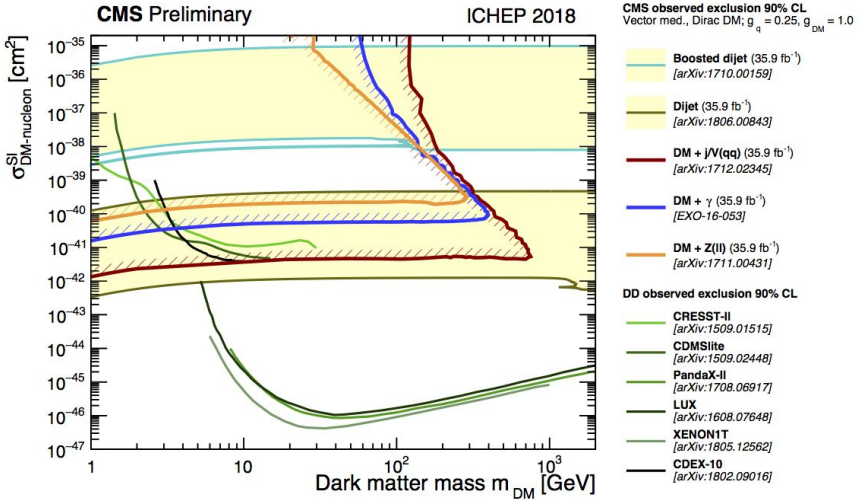
SM measurements and simplified models

- Turn absence of new physics signal into a precision measurement program
- Test SM EFT and theory simplified model predictions against SM precision measurements

See CONTUR

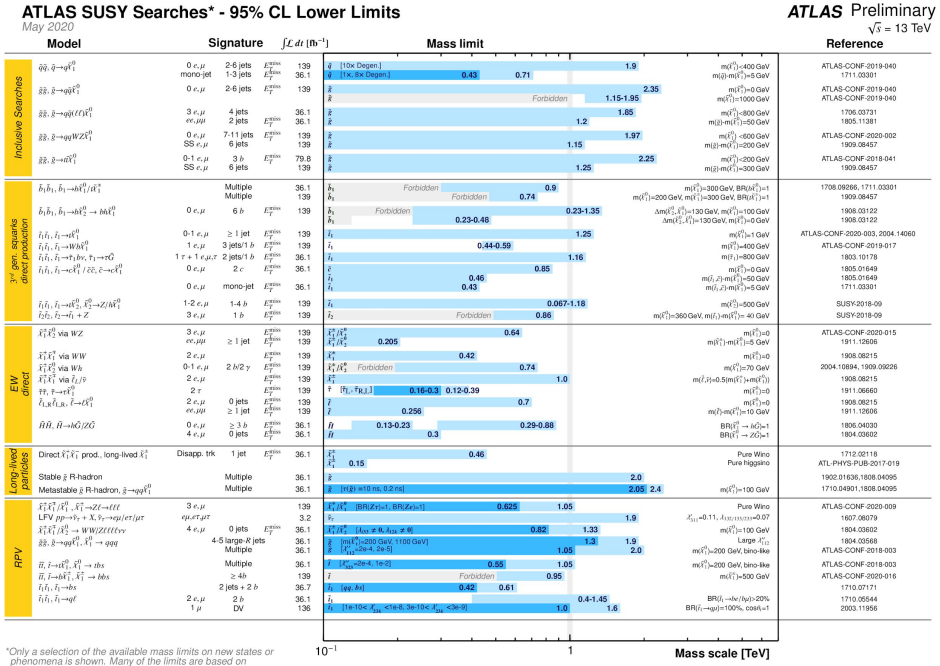
Simplified models - advantages

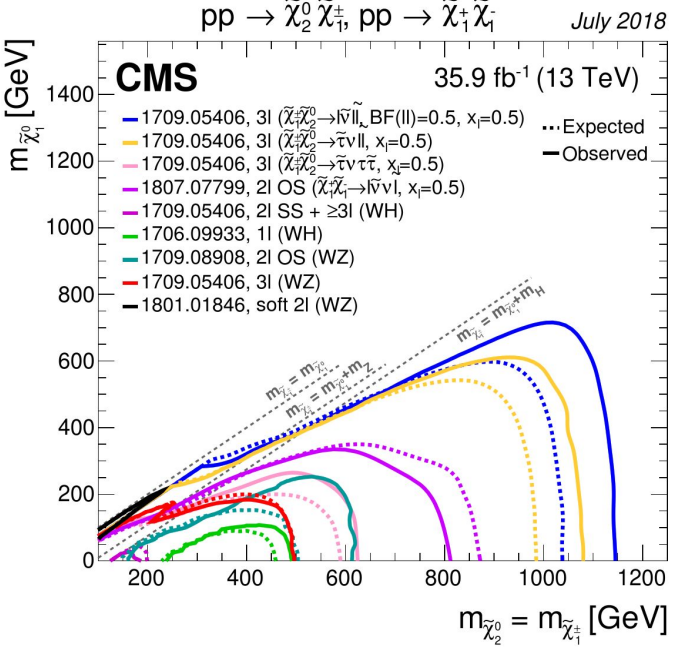
- Easy to use and understand
  - It is also important to put the LHC program in wider context, full models can be too complicated to understand for someone from outside the field, simplified models help communicate
- Easy to put different experiments on the same plane (DMWG)



Simplified models - advantages

- Easy to compare our own progress and search channels



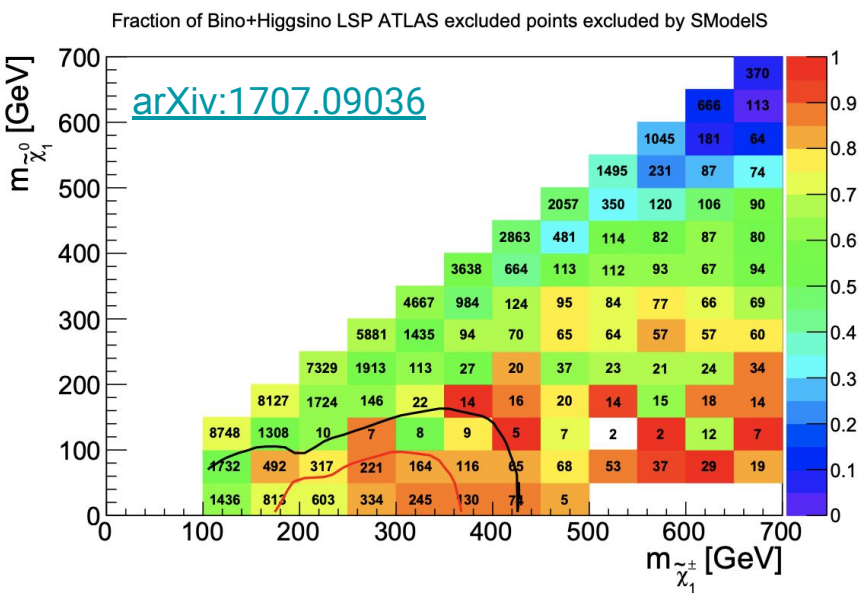


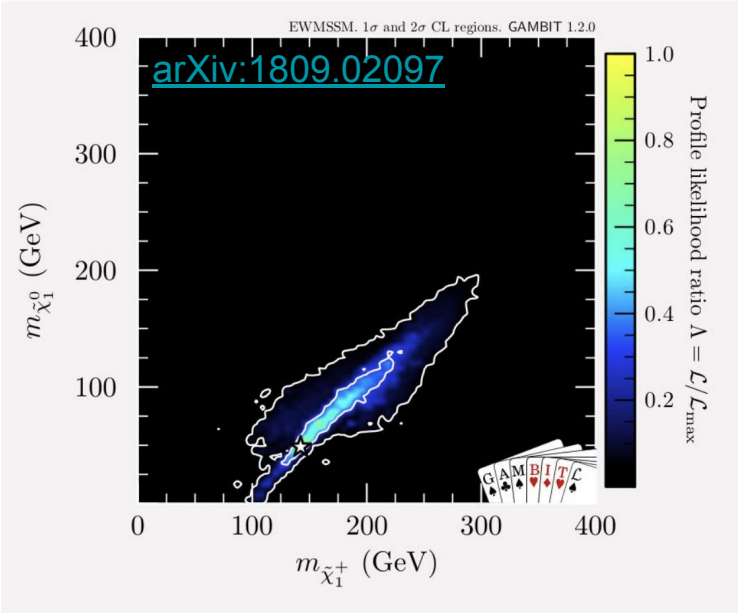
Simplified models - advantages (summary)

- Easy to handle experimentally
- Easy to compare our own progress
- Easy to evaluate dependence of quantum particle properties e.g. spin
- Reinterpretation (see also discussion in reinterpretation forum report arXiv:2003.07868)
- Easy to use and understand
  - It is also important to put the LHC program in wider context, full models can be too complicated to understand for someone from outside the field, simplified models help communicate
- Easy to put different experiments on the same plane (DMWG)

Simplified models - disadvantages

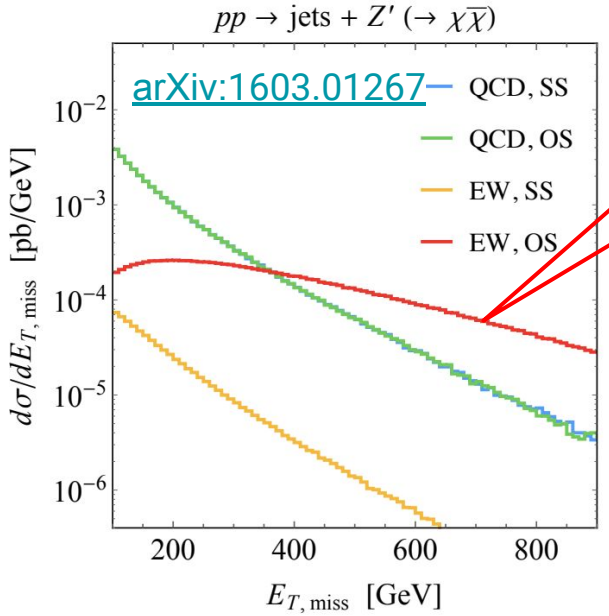
- Too conservative limits - lead to false sense of abandonment
  - "*Low scale susy is ruled out*"
  - Contrary, light electroweak sector still very much alive





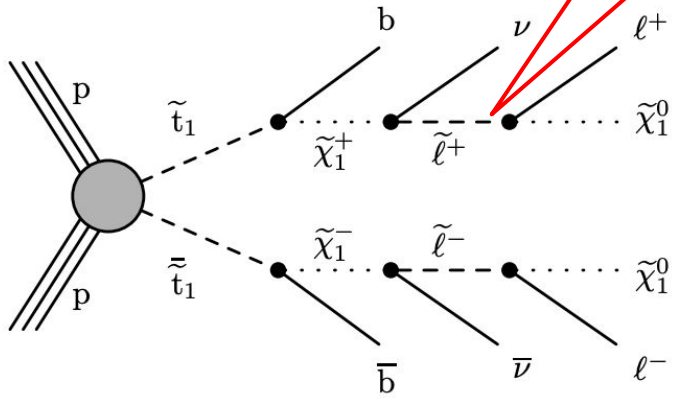
Simplified models - disadvantages

- Some simplified models can be unrealistic, or too fine tuned
  - Mono-W models violated unitarity
  - Topologies such as shown here (RHS) are too specific (and are considered by the experiments)



Artificial enhancement

Needs very particular mass arrangements



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- Some simplified models can be unrealistic, or too fine tuned
  - Mono-W models violated unitarity
  - Topologies such as shown here (RHS) are too specific (and are considered by the experiments)
- Simplified models can lead to limited signature space
  - Higgs to susy final states e.g. discussed by C. Wagner, M. Carena are possible only when considering both heavy Higgs and and electroweakino sectors
  - Long cascade decays in susy are not covered by existing simplified model topologies
  - Dark Higgs phenomenology in dark higgs dark photon models can be equally important

See talk by M. Pospelov

Simplified models - future directions

- Less simple simplified models - particularly useful for supersymmetry
- Upper limits vs/and efficiency maps
- DM WG going beyond mass coupling slices

  See talk by P. Harris, B. Gao
- Connecting DM@colliders and DM@accelerators (EF ↔ AF cross talk)

  See talk by N. Toro
- Defining benchmarks for new scenarios - dark showers, LLP(ongoing), fixed target experiments (PBC report, for beyond see talk by M. Pospelov)
  - Necessary to develop tools which will accept full model as input and predict simplified model topologies (SModelS does this for Z_2 conserving topologies, plans to extend)
- Simplified models and the EFT - in some limit simplified models and EFT can be matched onto each other
- Can we use simplified models to build full models?
- Simplified models for future colliders - too early to think about?

Conclusions

- Nature is likely not going to be simplified
- With low hanging fruits gone, we should start thinking about less simple simplified models
  - DMWG t-channel models
  - SUSY one step cascade decays
- We should be careful about drawing a boundary between simplified models and full models
- Don’t abandon the current simplified models yet, they reflect continuation of previous LHC legacy results
  - Work in progress within to show impact of assumptions for DM simplified models
- Defining simplified models for new new physics scenarios e.g. strongly interacting dark sectors will require a community effort and it is extremely crucial